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A Taxonomic Study of *Bryodrilus* (Enchytraeidae, Oligochaeta) from Changbaishan Mountain, China

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Three terrestrial species of *Bryodrilus*, a genus never recorded before in China, are described from Mt. Changbaishan, Jilin Province, north-eastern region of China. *Bryodrilus longifistulatus* sp. nov. is diagnosed by having 3-5 chaetae per bundle, an anterior convexity of the brain, a long sperm funnel, and numerous large spermathecal ectal glands; *B. macrotheca* sp. nov. is characterized by the presence of 6-8 spermathecal diverticula, bilobed penial bulbs, and an unpaired seminal vesicle. *Bryodrilus parvus* Nurminen, 1970 is recorded from the country for the first time.

Key Words: Enchytraeidae, Oligochaeta, *Bryodrilus*, new species, Mt. Changbaishan, China.

Introduction

Since Ude (1892) erected the enchytraeid oligochaete genus *Bryodrilus*, 11 taxa (including nine species and two subspecies) have been reported throughout the world (Nielsen and Christensen 1959; Dózsa-Farkas *et al.* 1985, 1992; Römbke and Dózsa-Farkas 1996). Among them, three species and one subspecies were described from Europe, *viz. B. ehlersi* Ude, 1982, *B. cejkai* Nurminen, 1980, *B. chernovi* Nurminen, 1980, and *B. ehlersi glandulosus* Dózsa-Farkas, 1990; two from Greenland, *viz. B. parvus* Nurminen, 1970 and *B. diverticulatus* Cernosvitov, 1929; two from arctic regions of Russia, *viz. B. borealis* Cejka, 1912 and *B. cockerelli* (Bell, 1947); and two species and one subspecies from Canada, *viz. B. novaescotiae* Bell, 1962, *B. arctica* (Bell, 1962), and *B. parvus kananaskis* Dash, 1970.

In 1993, a survey of soil invertebrates was carried out at Mt. Changbaishan in north-eastern China. Among the findings, *Bryodrilus*, a genus never recorded before in the country, was found. Herein, three species of this genus, including two species new to science, are reported.

Materials and Methods

Worms were extracted by the wet-funnel method (O'Connor 1962) and fixed in 10% formalin. For microscopical observation, whole worms were stained in borax carmine or paracarmine and mounted in Canada balsam. Measurements given in the descriptions are based on fixed specimens. Types of the new species are deposited in Specimen Room of Invertebrates, Institute of Hydrobiology, the Chinese

Academy of Sciences, China.

Bryodrilus Ude, 1892
(see Nielsen and Christensen 1959)

Diagnosis. Chaetae sigmoid or almost straight, without nodulus; those towards dorsal and ventral midlines of body gradually smaller. Head pore at 0/1. Dorsal pores absent. Peptonephridia and intestinal diverticula absent. Two pairs of oesophageal diverticula in VI. Transition between oesophagus and intestine gradual or somewhat abrupt in preclitellar region. Dorsal vessel originating in or behind clitellar region. Blood colourless. Coelomocytes of one type, uniform in size and shape. Interstitial tissue of nephridia well developed; anteseptale consisting of funnel only or some canals. Sperm funnels one pair in XI. Seminal vesicle present or absent. Spermathecae one pair, with or without diverticula; ental ducts united and communicating jointly with oesophagus.

Remarks. This genus is distinct from other genera of Enchytraeidae by the presence of two pairs of oesophageal diverticula in VI.

Bryodrilus parvus Nurminen, 1970
(Fig. 1)

Material examined. Five whole-mounted specimens.

Locality. Mt. Changbaishan (128°28′E, 42°35′N; ca. 740 m above sea level), Jilin Province, China, August 1993. Specimens were collected from brown soils of mixed forest with Korean pine dominant.

Description. Body length 3.5-4.7 mm (fixed). Segments 32-38. Epidermal glands abundant, 3-5 transverse rows per segment. Chaetae sigmoid, 40-65 μm long and 3-5 μm thick, those towards dorsal and ventral midline of body gradually smaller. Chaetae formula: 2, 3, 4-2, 3, 4 : 5, 6-4, 5, 6. Clitellum slightly elevated, in XII-XIII, its glands irregularly distributed. Two male pores separated, ventrolateral in middle of XII. Chaetae of XII absent at maturity.

Brain convex anteriorly and concave posteriorly, 101-104 μm long and 73-77 μm wide (Fig. 1A). Pharyngeal glands 3 pairs in IV-VI, none united dorsally. Anterior two pairs with ventral lobes. Two pairs of sponge-like and unbranched oesophageal diverticula in VI, one pair dorsally, the other ventrally, with thin walls and wide canals connecting with oesophagus (Fig. 1E). Transition between oesophagus and intestine somewhat abrupt in 7/8. Chloragogen cells scarce, beginning from V, granulated, containing oil globules and visible nucleus. Dorsal vessel originating in XII. Blood colourless. Nephridia from 4/5, with 7 pairs in front of clitellum. Anteseptal part small, containing nephrostome and some interstitial tissue; postseptal part elongate, ca. 3-4 times as long as anteseptals. Efferent duct originating mid-ventrally (Fig. 1B). Coelomocytes discoid, evenly granulated, 14-16 μm in diameter.

Seminal vesicles absent. Sperm funnels confined to XI, cylindrical, 46-50 μm long and 26-28 μm wide, collar as wide as body of funnel (Fig. 1C). Vasa deferentia short, confined in anterior part of XII, 3-4 irregularly coiled loops. Penial bulb

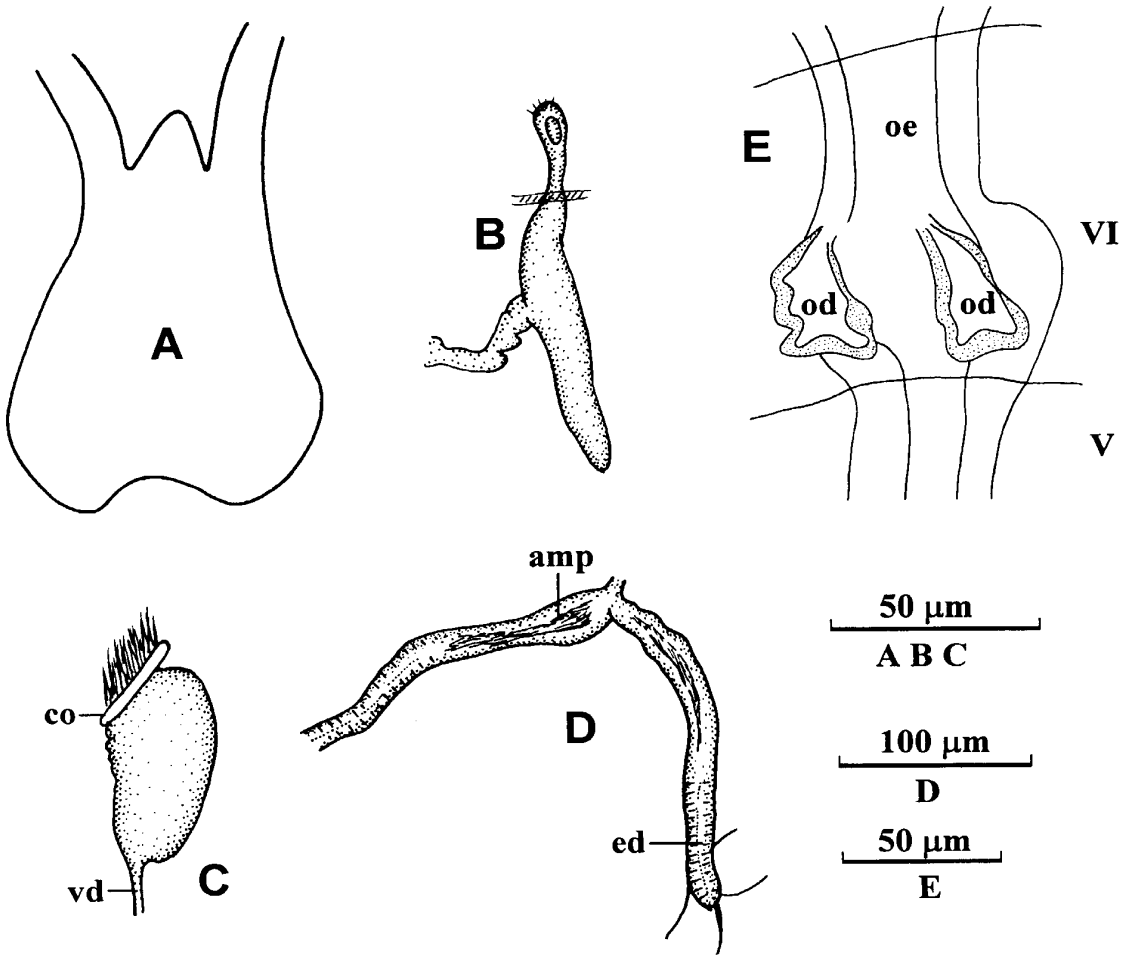

Fig. 1. *Bryodrilus parvus* Nurminen, 1970. A, brain; B, nephridium in 7/8; C, sperm funnel; D, spermatheca, E, dorsal view in V-VI, showing the dorsal pair of oesophageal diverticula. Abbreviations: amp, ampulla; co, collar; ed, ectal duct; od, oesophageal diverticula; oe, oesophagus; vd, vasa deferentia.

small, "lumbricilline-type", 38-40 μm long, 31 μm wide, 30-32 μm high. No special copulatory glands. No egg sac; 1-3 mature eggs present at a time.

Spermathecae 1 pair in V (Fig. 1D). No ectal glands at spermathecal pores. Ectal duct short with thick wall, 60-65 μm long and 16-18 μm wide. Ampulla slightly longer and wider than ectal duct, with thin wall, 90-100 μm long and ca. 20 μm wide. Copulatory spermatozoa scattered in lumen. Two very short ental ducts with short common duct communicating with oesophagus in posterior of V.

Distribution. Greenland (Nurminen 1970), Canada (Dash 1970), Iceland (Nurminen 1973), Ireland (Healy 1979), Austria (Nurminen 1977), Sweden (Rota *et al.* 1998). New for China.

Remarks. In spite of the incomplete description of the details of the pharyngeal glands, the position of the first nephridia, and other organs, most of the morphological characters of our specimens conform to the original descriptions of *Bryodrilus parvus* by Nurminen (1970) and *Bryodrilus parvus kananaskis* by Dash (1970), the latter having been regarded as identical with *B. parvus* per se (Dózsa-

Farkas *et al.* 1992). Nurminen (1970) described the oesophageal diverticula of *B. parvus* as roundish, devoid of internal lumen and pulsation *in vivo*, and he also noted an intestinal dilatation in IX-X. In our specimens, however, the oesophageal diverticula are sponge-like with thin wall and a distinct chamber, and the transition between oesophagus and intestine is abrupt at 7/8. Since no living specimens were observed, we prefer to regard this variability as intraspecific rather than interspecific. The species is easily distinguished from any other species of *Bryodrilus* without ectal glands by the smaller body size of mature individuals.

Bryodrilus longifistulatus sp. nov.
(Fig. 2)

Holotype. Whole-mounted mature specimen.

Type locality. Mt. Changbaishan (128°28′E, 42°35′N; ca. 740 m above sea level), Jilin Province, China, August 1993. Specimens were collected from brown soils of mixed forest with Korean pine dominant.

Paratypes. Four whole-mounted specimens, from same date and locality as holotype.

Other examined materials. Ca. 50 specimens in total from same date and locality as holotype, preserved in 10% formalin.

Etymology. Named for the very long sperm funnels.

Description. Body length 15-24 mm (holotype 17.3 mm). Segments 58-72 (holotype 59). Epidermal glands poorly developed, only 2-3 transverse rows per segment. Head pore round, large, in 0/1. Dorsal pores absent. Chaetae sigmoid, those towards dorsal and ventral midlines of body gradually smaller. Chaetae formula: 2, 3, 4, 5, 6-2, 3, 4: 3, 4, 5, 6, 7-3, 4, 5, 6. Maximal length of chaetae 182-185 μm, and ca. 12 μm in maximal thickness. Clitellum slightly elevated, in XII-XIII, clitellar glands scattered. Two male pores separated, ventrolateral in middle of XII. Chaetae of XII missing in mature specimens.

Brain in I-II, convex anteriorly and concave posteriorly, ca. 181 μm long and 141 μm wide (Fig. 2A). Pharyngeal glands massive, 3 pairs in IV-VI, all with distinct ventral lobes and separate dorsally; anterior pair elongate. Gradual transition between oesophagus and intestine. Two pairs of pouch-like, unbranched oesophageal diverticula in VI, one pair dorsally and one pair ventrally, each with thin wall and large central chamber in wide communication with oesophagus (the same as in *B. macrotheca*, see Fig. 3B). Chloragogen cells sparse, from VII onwards, containing granules, oil globules, and visible nucleus. Dorsal vessel originating in XVII. Blood colourless. Nephridia from 5/6, with 6 pairs in front of clitellum. Anteseptal part small, with separate nephrostome and some interstitial tissue; postseptale elongate, its narrow efferent duct arising antero-ventrally, near septum (Fig. 2B). Coelomocytes discoid, very abundant, especially in posterior few segments, 27-30 μm in diameter.

Seminal vesicles absent. Sperm funnels cylindrical, extending forward to X, 1340-1410 μm long and 157-263 μm wide, collar distinct, 275-283 μm wide (Fig. 2C). Vasa deferentia confined to XII, irregularly coiled, ca. 27 μm wide. Penial bulbs compact, hemispherical in lateral view, 338-346 μm long, 275-307 μm wide, and 291-297 μm high. Egg sac absent; only one mature egg present at a time.

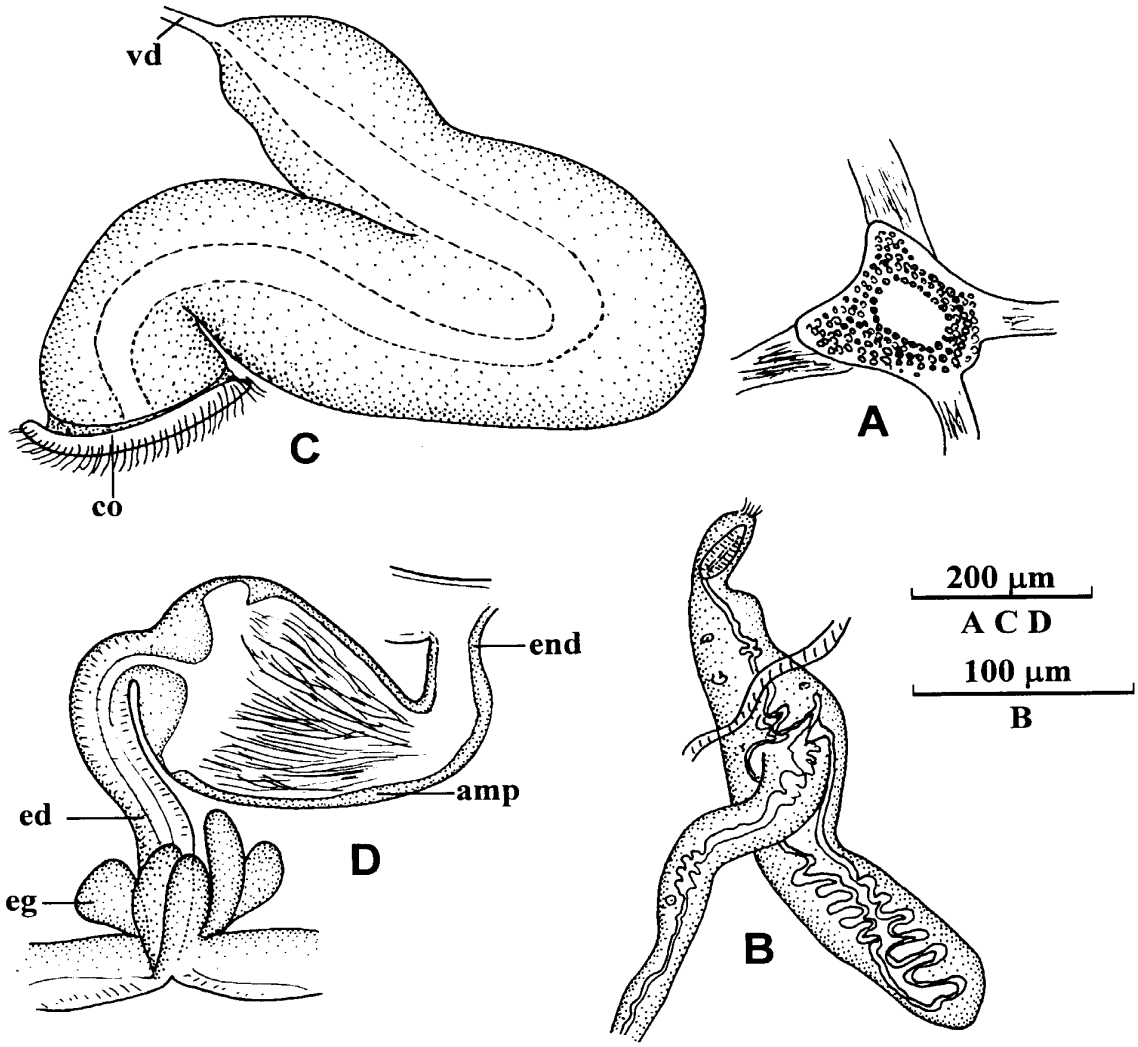

Fig. 2. *Bryodrilus longifistulatus* sp. nov. A, brain; B, nephridium in 13/14; C, sperm funnel; D, spermatheca. Abbreviations: amp, ampulla; co, collar; ed, ectal duct; eg, ectal glands; end, ental duct; vd, vasa deferentia.

Spermathecae in V-VI, each consisting of an ampulla, ectal duct with thick walls, and wide ental duct (Fig. 2D). Ampulla onion-shaped, 350-360 μm long and ca. 260 μm wide, its lumen containing large quantities of scattered spermatozoa. Ectal duct stout, 433-450 μm long and ca. 66 μm wide, 4-6 large gland cells around each ectal pore. Ental duct stout, with thin wall, 157-165 μm long and ca. 70 μm wide. The two ental ducts merging near mid-dorsum of 5/6 into a short, narrow, common duct, this communicating with oesophagus dorsally in middle of VI.

Remarks. The new species is somewhat approximated to the arctic *B. cockerelli* and *B. borealis* by the body size and the presence of spermathecal accessory glands at the ectal pores. However, it differs from *B. cockerelli* by having more chaetae per bundle; by the anterior convexity of the brain, the unbranched oesophageal diverticula in VI, the position of the first nephridia and their larger preseptal part, the unlobed postpharyngeale, and the origin of the efferent duct; and

by possessing more ectal glands at the ectal pores. It differs from *B. borealis* by having more chaetae per bundle, an anterior convexity of the brain, a more extended dorsal vessel, longer sperm funnels, and shorter spermathecal ectal ducts with larger ectal glands (see Cejka 1912; Bell 1947).

In addition, the new species is also close to *B. cejkai* in terms of the large body size, the origin of the dorsal vessel, and the absence of seminal vesicles, but it is obviously distinct from *B. cejkai* by the longer sperm funnel and the presence of spermathecal ectal glands (see Nurminen 1980).

Bryodrilus macrotheca sp. nov.
(Fig. 3)

Holotype. Whole-mounted mature specimen.

Type locality. Mt. Changbaishan (128°28′E, 42°35′N; ca. 740 m above sea level), Jilin Province, China, August 1993. Specimens were collected from brown soils of mixed forest with Korean pine dominant.

Paratypes. Four whole-mounted specimens, also from same date and locality as holotype.

Other examined materials. Ca. 20 specimens in total also from same date and locality as holotype, preserved in 10% formalin.

Etymology. Named for the very large spermathecal ampullae.

Description. Body length 9-14 mm (holotype 14 mm). Segments 46-63 (holotype 63). Head pore round, large, in center of I segment. Dorsal pores absent. Epidermal glands scarce. Chaetae sigmoid, unequal in a bundle, 70-126 μm long and 5-9 μm wide, those towards dorsal and ventral midlines of body gradually smaller (Fig. 3A). Chaetae formula: 3, 4-3, 4, 5 : 4, 5-4, 5. Clitellum in XII-XIII, slightly elevated, its glands oblong, 7-12 μm in size, irregularly distributed. Two male pores separated, ventrolateral in middle of XII. Chaetae of XII absent at maturity.

Brain trapezoidal, very concave anteriorly and slightly concave or truncate posteriorly, 141-174 μm long and 90-100 μm wide. Primary pharyngeal glands 3 pairs in 4/5, 5/6, 6/7, all with developed ventral lobes, first pair united dorsally, the others separated. Transition between oesophagus and intestine somewhat abrupt in 5/6 (Fig. 3B). Two pairs of stalked, unbranched oesophageal diverticula in VI, one pair dorsally and one pair ventrally, each with thin wall and large central chamber in wide communication with oesophagus (Fig. 3B). Chloragogen cells sparse, commencing in V. Dorsal vessel originating from XVI. Blood colourless. Nephridia from 4/5, 6 pairs in front of clitellum, anteseptal parts containing nephrostome and some interstitial tissue; efferent ducts originating from antero-ventral region of postseptal parts near septum (Fig. 3C). Coelomocytes of one type, numerous, discoid, 35-38 μm in diameter, with regular outline and evenly distributed granules.

Seminal vesicle unpaired, extending forwards to X and backwards into mid-XII. Sperm funnel cylindrical, 551-669 μm long and 147-194 μm wide, with raised collar wider than funnel (Fig. 3D). Vasa deferentia confined to XII, irregularly coiled. Penial bulbs each with 2 compact, muscle-covered, glandular masses, one extending anteriad, the other posteriad. Anterior one cylindrical in lateral view, 136-150 μm long, 80-89 μm wide, 252-270 μm high. Posterior one sector-shaped in lateral view, ca. 350 μm long, 248 μm wide, 178 μm high (Fig. 3D). No egg sacs; 1-2 eggs pres-

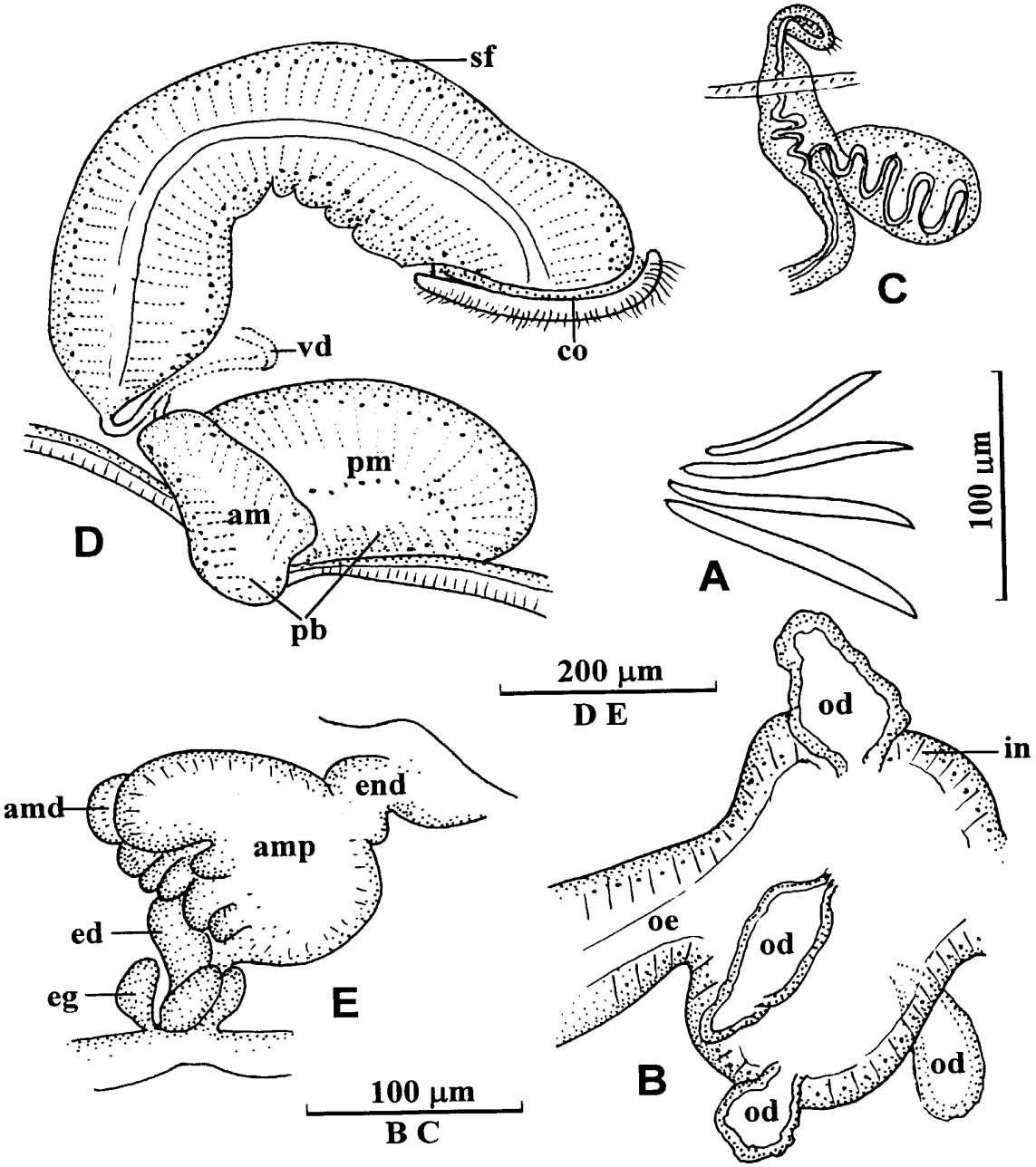

Fig. 3. *Bryodrilus macrotheca* sp. nov. A, chaetae in V; B, dorsal-lateral view in V and VI, showing the oesophageal diverticula and the abrupt transition between the oesophagus and intestine; C, nephridium in 15/16; D, male organs, showing sperm funnel and penial bulb; E, spermatheca. Abbreviations: am, anterior mass; amd, ampullar diverticula; amp, ampulla; co, collar; ed, ectal duct; eg, ectal glands; end, ental duct; in, intestine; od, oesophageal diverticula; oe, oesophagus; pb, penial bulb; pm, posterior mass; sf, sperm funnel; vd, vasa deferentia.

ent.

Spermathecae paired in V-VI, each having subspherical ampulla and 6-8 diverticula of various sizes (Fig. 3E). Spermatozoa scattered throughout common lumen

of ampulla and diverticula. Ampullae occupying almost all of V, ca. 259-270 μm in diameter. Ental ducts with thin wall, ca. 116 μm long and 70 μm wide, the pair forming a common duct before communicating with dorsolateral region of oesophagus in VI. Ectal ducts with thick wall, ca. 252 μm long and 51 μm wide, with 2-3 large accessory glands at each ectal pore.

Remarks: Compared to all known species of *Bryodrilus*, the new species possesses two unusual features: spermathecae with 6-8 diverticula, and bilobed penial bulbs. The new species is similar to *B. longifistulatus* described above, *B. borealis*, and *B. cockerelli* in body size and the presence of large accessory spermathecal glands. Besides these exceptional features, the new species also differs from *B. longifistulatus* by the anterior concavity of the brain, fusion of the first pair of pharyngeal glands, an abrupt transition between the oesophagus and intestine at 5/6, the number of nephridia in front of the clitellum, and the presence of an unpaired seminal vesicle; from *B. borealis* by possessing more chaetae per bundle and a seminal vesicle; from *B. cockerelli* by the unbranched oesophageal diverticula, the unlobed postseptal part of the nephridia, the presence of a seminal vesicle, and the shorter sperm ducts (see Cejka 1912; Bell 1947).

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